Factors of air-rail intermodality

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Abstract

European transport policy promotes intermodality as a means of improving efficiency and sustainability. This study looks into passenger air-rail intermodality at airports which are directly integrated into long-distance rail networks and focuses on intermodal journeys in which the rail trip doesn't serve the purpose of city-centre to nearby airport access, but rather makes up a substantial leg of the journey, potentially substituting short-haul air feeders and expanding airport catchment areas. Air-rail intermodality projects involve considerable capital and operating costs and require ambitious goals and strong cooperation among actors. Although best practice guidelines exist for intermodality in general, there doesn't seem to be one best solution for air-rail intermodality success. By examining literature, European intermodal products and rail stations at airports, we propose five critical success factors: infrastructure integration, network context, overall travel time and transfer time, integrated ticketing and information. Governance factors were also found to be a key determinant of success for planning, implementing and operating these multi-operator projects which require high levels of coordination. Case studies examined best practice (Frankfurt airport) and compared a successful case with one which is not so successful (Paris-CDG versus Lyon Saint-Exupéry). Result transferability to Portugal was analyzed, focusing on Lisbon airport. As a result, we suggest three issues be taken into account when assessing the integration of Lisbon airport into the high-speed rail network – sufficient demand to justify adequate rail frequencies, sufficient provision of long-haul flights from Lisbon airport to capture demand and the existence of operator interest in offering intermodal products.

Keywords

Air-rail intermodality, intermodal integration, substitution, airports, air transport, rail transport

1. Introduction

Air transport networks develop as combinations of different forms. One can easily distinguish point to point networks from hub and spoke networks: the former provide a direct service connecting A to B, the latter connect several Ai and Bi nodes to a transfer node K – the *hub* – where interconnecting Ai-Bi passenger traffic is grouped and rearranged. The key concept of hub and spoke networks is the consolidation of traffic flows from various origin airports (spoke links) on a hub from which flows are redirected. This consolidation allows loading of larger seat number long-haul intercontinental flights. It is straightforward to envision that any of the *air spokes* may be replaced by a *rail spoke*, as long as rail infrastructure and service are in place and adequate transfer is provided, as in the case of airplane to airplane – luggage transfer, integrated ticketing, people moving solutions for larger distances between terminals, etc. This type of substitution may come about when the rail leg is under 3 hours, up to 1000 km (EC, 1998). Also, additional *rail spokes* may be added to the existing networks for destinations without airports, expanding the hub's catchment area.

In the scenarios above, there is complementarity between air and rail in providing an intermodal journey where the intermediate node (the hub) acts as a platform for mode transfer. The European Commission (EC) defines intermodality as "a characteristic of a transport system that allows at least two different modes to be used in an integrated manner in a door-to-door transport chain" (EC, 1997). It is possible to list two defining features of intermodal transport: the use of more than one mode of transport to complete a journey and the coordination between those modes of transport in providing a travel service. In air transport, it is important to distinguish between intermodal travel in which one mode solely performs airport ground access and intermodal travel in which the land leg corresponds to a substantial part of the journey (Eurocontrol, 2004).

This study looks into passenger air-rail intermodality at airports which are directly integrated into long-distance rail networks and focused on the latter type of intermodality, potentially substituting short-haul air feeders and expanding airport catchment areas. Our purpose was to find out which factors determine air-rail intermodality success and in what conditions air-rail intermodality could be a success in Portugal.

2. Methodology

This study was carried out in 5 steps. Firstly, we reviewed three important framework issues: European policy, actors and their motivations and concerns about air-rail intermodality, and the definition of air-rail intermodality success. Secondly, we observed the current European situation, i.e. existing railway stations at airports and available air-rail products. Thirdly, we listed factors for air-rail intermodality success and identified the critical ones and their relation to actors and domains of success. Three case studies followed – we examined best practice at Frankfurt Airport, compared success case Paris-CDG with not so successful case Lyon Saint-Exupéry and attempted to transfer results to Portugal. Finally, we produced recommendations and notes on results transfer.

3. Passenger intermodality in European transport policy

Intermodality has been an important goal of EU transport policy. The 1995 EC transport Green Paper (EC, 1995) determined the need to offer integrated and intermodal services for passengers. In 2001, the EC transport White Paper (EC, 2001) identified integrated ticketing, baggage handling and continuity of journeys as the key priority issues for intermodal passenger transport. In pursuing the 2001 White Paper policy, the EU funded research into the possibility of extinguishing air routes on links where competitive high-speed services exist and transferring air capacity to links where no high-speed rail service exists (EC, 2001). In 2006, the mid-term review of the 2001 White Paper introduced the concept of co-modality, which highlights efficiency and sets as a goal the optimal use of the transport system (EC, 2006b). In a co-modality framework, modal shift occurs where it is socio-economically desirable (Riley and Kumpoštová, 2010). Current EU transport policy is directed by the 2011 White Paper (EC, 2011), which proposes seamless door-to-door mobility as an initiative to achieve efficiency, specifically in the field of service quality, comprising the definition of measures necessary for further integrating different passenger transport modes and the development of framework conditions to promote the development and use of intelligent systems for interoperable and multimodal scheduling, information, online reservation systems and smart ticketing.

4. Railway stations at airports

We found that three main criteria are used to classify airport rail links: firstly, service range distinguishes between airport to city-centre links, connections to the urban or suburban rail network, links which integrate airports into the national rail network and connections to international high-speed networks; secondly, service type, which sorts intercity, regional and high-speed services; thirdly, link design, which describes the airport rail link configuration and makes it possible to distinguish between dedicated lines and stations on main line, branch or spur lines on the national network. We chose to classify air-rail links according to the first two criteria and obtained the categories defined on Table 1.

Service range	Service type	Definition	Example
City / Urban	Dedicated airport to city-centre line	Dedicated rail service directly from a city-centre to the airport, without needing to change trains, mostly without intermediate stops.	Stockholm-Arlanda (ARN): Arlanda Express
	Metro	Urban public transport service provided by metro, with a station at the airport.	London-Heathrow (LHR): London Underground's Piccadilly Line
	Light rail / tram	Urban public service provided by light rail or tram, with a stop at the airport	London-City (LCY): Docklands Light Railway
National railway network	Local / suburban trains	Public transport service provided by local or suburban trains with a station at the airport	Stockholm-Arlanda (ARN): Upptåget service
	Long-distance conventional	Long-distance transport service provided by conventional trains with a station at the airport	Zurich (ZRH): InteRegio and Intercity services by SBB-CFF-FFS
	High-speed trains	Long-distance transport service provided by high-speed trains with a station at the airport	Paris-CDG (CDG): Ligne Grande Vitesse Interconnexion Est

Table 1 – Categorization of airport rail links adopted in this study

For the categories relevant for our study – the last two – we made an inventory of existing rail stations at European airports (listed below), and associated rail operators.

- Long-distance conventional: Amsterdam-Schiphol (AMS), Birmingham (BHX), Brussels (BRU), Budapest (BUD), Cologne/Bonn (CGN), Copenhagen Kastrup (CPH), Düsseldorf (DUS), Frankfurt (FRA), Friedrichshafen (FDH), Geneva (GVA), Glasgow-Prestwick (PIK), Leipzig/Halle (LEJ), London-Gatwick (LGW), London-Luton (LTN), London-Stansted (STN), London-Southend (SEN), Lübeck Blankensee (LBC), Manchester (MAN), Milan-Malpensa (MXP), Oslo-Gardermoen (OSL), Paris-CDG (CDG), Pisa Galileo Galilei (PSA), Rome Leonardo da Vinci-Fiumicino (FCO), Southampton (SOU), Stockholm-Arlanda (ARN), Trondheim (TRD), Zurich (ZRH)
- High-speed trains: Amsterdam-Schiphol (AMS), Brussels (BRU), Cologne/Bonn (CGN), Copenhagen Kastrup (CPH), Düsseldorf (DUS), Frankfurt (FRA), Leipzig/Halle (LEJ), Lyon-Saint Exupéry (LYS), Paris-CDG (CDG)

5. Air-rail products in Europe

There are many successful air-rail intermodal products in Europe which are the result of operator agreements. We selected five intermodal products and studied their main features (Table 2): TGVAir in France, Rail&Fly and AIRail in Germany and FlugZug (Basel) and FlyRailBaggage in Switzerland. There are many other agreements between operators in Europe which result in different products with varying degrees of seamlessness. Code-sharing agreements allow trains to be assigned airplane codes and be sold through common channels. Many non-European airlines flying into Europe have code-sharing agreements for their intercontinental flights.

	Intermodal air-rail products				
Main features	**TGVAir**	**Rail&Fly**	**Flugzug**	**FlyRailBaggage[(8)]**	**AIRail**
Integrated ticketing	•		•	•	•
Common online ticket distribution	•	• (1)	•		•
Baggage handling			(2)	•	

	Intermodal air-rail products				
Main features	**TGVAir**	**Rail&Fly**	**Flugzug**	**FlyRailBaggage**[(8)]	**AIRail**
Schedule coordination	•		• [(3)]		•
End to end check-in	•		[(2)]		•
"Airplane grade" train on-board service	•				•
Frequent flyer miles	•		•		•
Delay/connection assistance	•		•		•
High number of possible destinations	• [(4)]	•	•	• [(5)]	
Booking flexibility		• [(6)]		• [(7)]	

[(1)] Available only in very few cases.
[(2)] Available at an additional cost.
[(3)] Although no schedule coordination is advertised by the operators, high frequencies allow for short connection times.
[(4)] 20 rail destinations potentially available, but that number depends on the specific airline agreement; Air France, for example, offers 9 possible rail destinations by TGVAir.
[(5)] Advertised to be available from all airports in the world.
[(6)] Within a day of the air trip, all partner trains are available with very few exceptions.
[(7)] Within a day of arrival, baggage will be stored for free at the rail station; after that a storage fee is charged.
[(8)] Some of the features don't apply, as this service carries baggage, not passengers.

Table 2 – Summary of main features of intermodal products in Europe

TGVAir and AIRail are full featured intermodal products which were built specifically to attract air-air travelers, potentially allowing the substitution of feeder flights to major hubs Paris-CDG and Frankfurt, respectively. It is interesting to notice that even these products are not able to offer through baggage handling. AIRail's system was in place for some years at the cost of significant investment, but it was eventually discontinued for operational and security issues. In this way, from this group of products, the successful baggage handler is a separate product which is not concerned with the transport of the baggage *owners* – Fly Rail Baggage. The passenger might even fly on the same airplane as the baggage, but baggage is handled as cargo or mail from origin to destination. Flugzug Basel will handle baggage, but this is not as a feature of its product package, rather as an additional service at an extra cost.

6. Factors of air-rail intermodality success

Travel time, notably including schedule coordination, and integrated ticketing are the factors which are most mentioned by related literature. Ease of transfer factors related to physical issues, baggage handling and end to end check-in are also mentioned in most studies.

Overall journey time and price are important factors for air-rail intermodality success (Cokasova, 2006; DGAC, 2009), but their relative importance varies with the demand segment we are considering – typically, time is an issue for business passengers, especially those on trips within Europe, as opposed to longer intercontinental trips; price is an issue for all leisure passengers (AEROAVE, 2011).

Travel time in an intermodal journey is a sum of a lot of different parts, each depending on different factors (Figure 1). Air-rail intermodal products seem to be more successful when the air leg is an intercontinental long-haul flight, making the rail leg time a lot smaller in comparison and therefore more acceptable to the passenger. Recent data from French civil aviation shows that average flight time for intermodal passengers at Paris-CDG is about 8h (DGAC, 2009).

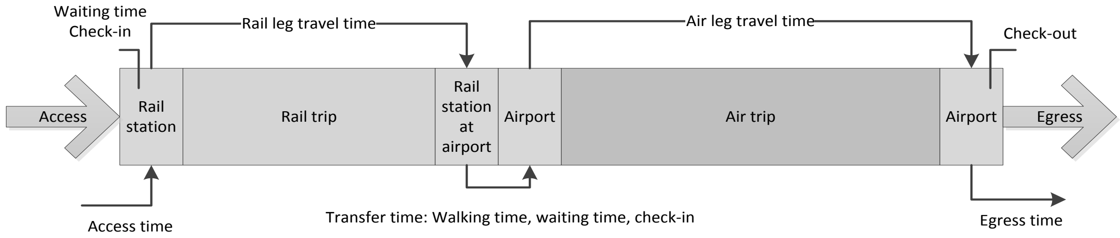

Figure 1 – Components of overallpassenger travel time in air-rail intermodality

One of the main reasons stated by passengers for not using air-rail intermodal travel is "connection issues" (IATA, 2003; DGAC, 2009, among others). These need to be addressed in order to provide seamless intermodal journeys. There are extensive guidelines on how to provide seamless travel (see KITE, 2009b), including design aspects of the intermodal interchange and passenger services to support intermodality such as schedule coordination, which is a factor of major importance for the development of air-rail intermodality, as it decreases transfer time and enables connection opportunities. Higher rail frequencies will also decrease waiting time and enable connections (Chi and Crozet, 2004). Another central issue related to ease of transfer is the adequate provision of information (on arrival and departure times, further connections, delays or breakdowns and platforms/gates) and directions (signposting). Although considered essential by many authors, through baggage handling and end to end check-in entail high investment and operating costs and raise security issues (Grimme, 2007).

Network context is decisive for air-rail intermodality (Chi and Crozet, 2004) – setting up air-rail links is more likely to be successful in a context: where there are rail connection opportunities (sizeable urban agglomerations) within 3 hours travel time, and rail infrastructure is mostly in place, with available train slots, at airports which offer varied and frequent long-haul flights; at airports with high passenger volumes to justify rail integration investment. Airports must generate enough passenger demand to make it attractive for rail operators and rail infrastructure managers to invest on and operate a link (AEROAVE, 2011).

Reliability and punctuality as transport product attributes are extremely important when there is competition (EC, 2006a), which is mostly the case with intermodal products, but also in a context where coordination is essential. In fact, passengers' perception regarding intermodal transport can be a barrier to the success of air-rail intermodality, mostly due to expectations of poor connection conditions and due to the image of rail transport in some countries (Eurocontrol, 2005). Among passenger concerns over using two different modes of transport on an intermodal journey of this type is a major apprehension over what happens in case of a missed connection if two operators are involved – who takes responsibility and who does the passenger address to solve their problem? Assistance agreements in case of delays or cancellations are therefore considered a product strength (IATA, 2003).

Even an intermodal product which meets most passenger needs will not be competitive if it is not marketed properly. Information and promotion are essential to force passenger demand (KITE, 2009b). Product visibility is necessary, and distribution over the internet is becoming increasingly important; also, common distribution, even if ticket integration doesn't exist, is decisive – while buying a ticket from any channel (airline website, travel agent, airline phone service, airport counter etc.), the customer is informed of rail feeders as well as air feeders, and has the option of purchasing either. The convenience of integrated ticketing helps the passenger perceive the intermodal journey as a single journey and not the sum of different legs (AEROAVE, 2011).

Good marketing stands on an excellent supply of information, which must be obtained through cooperation between operators and permanent and/or periodical campaigns for customer feedback. Continuous quality management with appropriate tools is a vital success factor (KITE, 2009b). There are many different kinds of intermodal service agreements between operators and these may involve other actors besides rail and air transport operators, namely airport managers, rail infrastructure managers, city managers, or police (KITE, 2009b).

There is such a large number of interrelated factors impacting on the development of intermodality – ease of access/egress, ease of transfer at airport (physical, logical and related to baggage and check-in), travel time, frequency, schedule and capacity, reliability and punctuality, delay assistance, connection opportunities and passenger volumes, mode preference, ticket price, rail on-board comfort and customer service, passenger incentives (such as frequent flyer programmes), flexibility, security, integrated ticketing, marketing, governance and legal and regulatory factors. These factors have intricate relationships, making it very complex to analyze them, be it individually or in groups.

Our approach was to group them in order to answer the question: "in which context is air-rail intermodality more likely to succeed?", which lead us to propose five critical factors of intermodality success:

Critical factor	**Description** **"Air-rail intermodality is more likely to succeed…"**
Infrastructure integration	At airports which have or plan to have railway stations
	At airports where spatial or project design constraints allow for good infrastructure integration, making the transfer between rail station and terminal as short, easy and comfortable as possible for the passenger
Network context	Where there are direct rail connection opportunities (sizeable urban agglomerations) within 3 hours travel time
	Preferably where rail infrastructure is mostly in place, with available train slots
	At airports which offer varied and frequent long-haul flights
	At airports with high passenger volumes to justify rail integration investment
Overall travel time and transfer time	On routes where it is possible to offer overall travel times which are competitive with air-air products
	Where operators agree to coordinate schedules to offer short waiting times at the intermodal transfer
Integrated ticketing	Where operators agree to offer integrated booking and purchase of intermodal tickets – one ticket for the entire intermodal journey
Information	Where operators agree to market their intermodal products adequately and to exchange information for their set up and operation

Table 3 – Critical factors of air-rail intermodality

We then looked for their interrelations with the initial factors in our literature review and found that all critical domains relate to governance and legal/regulatory factors. This shows us they are also critical as foundations of intermodal projects – legal/regulatory constraints strongly determine context and governance is key for planning, implementing and operating these multi-operator projects which require high levels of cooperation and coordination.

7. Case study results

Our first case study looked into best-practice in air-rail intermodality – Frankfurt airport and the Frankfurt-Cologne route. There is a long-distance train station with a dedicated AiRail terminal at the airport. Transfer is easy and comfortable, although not as short as transferring between Lufthansa flights (however, that should depend on the terminals involved). There are many direct rail connection opportunities within 3 hours travel time – the catchment is over 38 million inhabitants. Rail infrastructure in place allows for 39 stations to be reached by high speed rail services within 3 hours journey time. 167 high-speed rail services are offered each day from Frankfurt airport to those 39 stations. Frankfurt airport offers varied and frequent long-haul services as an intercontinental hub for Lufthansa and Star Alliance. Annual passenger throughput at the airport is 53,5 million (data for 2008) which makes it the 3rd busiest airport in Europe in terms of passenger numbers; over 50% of passengers at Frankfurt airport are transfer passengers. In 2002, rail travel time between Cologne and Frankfurt airport was reduced from 2 hours to 50 minutes with the introduction of high-speed services. As a consequence, demand for air services was considerably reduced. The introduction of the AirRail intermodal product further decreased air demand (and supply) in 2003. Train services did not fully replace air services until 2007. The Frankfurt-Cologne route is currently offered by AiRail in 50 minutes, with a frequency of 16 daily links – a high frequency which allows for considerably low waiting times for the intermodal passengers. AiRail offers integrated booking and ticketing through code-sharing; it is distributed online at numerous websites, notably from Lufthansa. AiRail is a joint venture of Lufthansa, DB and Fraport. Marketing tools have been used to start the product, define its features, monitor performance and adapt it. Cooperation and coordination of activities, as well as all the information exchange needed between actors is facilitated by an intermodal manager at the airport.

Our second case study looked into what makes airports succeed in air-rail intermodality by comparing a successful case with one which is not so successful (Paris-CDG versus Lyon Saint Exupéry). Based on available data and literature, we point to four key differences in transport supply which can account for the differences in intermodal passenger demand between Paris-CDG and Lyon. The first one is airport size in passenger volume. Railway stations at these airports aren't part of the rail networks which serve the cities; rather they are part of a high-speed rail network which avoids city centres (Chi and Crozet, 2004). Therefore, they need to become destinations on their own to justify the operation of trains which avoid urban agglomerations. Airport size in passenger volume here works a measure of how much an airport can stand on its own as a destination and make rail operation viable. Paris-CDG is about 8 times the size of Lyon airport in air passenger numbers (DGAC, 2011). In 2010, it was 2nd in the European ranking of airports by passenger volume, whereas Lyon was 49th. The second key difference is rail frequency, which comes as a consequence of the first. During the period of analysis, very low frequencies were offered for high-speed rail links from Lyon, and since schedule coordination wasn't a concern, intermodal transfer times became very high; moreover, with frequent air transport delays, the possibility of a missed connection with a very low frequency train becomes a major hindrance for the passenger (Chi and Crozet, 2004). The third key difference is the provision of intercontinental long-haul flights at the airport. While Paris-CDG is one of three major intercontinental hubs for Europe, Lyon is a regional platform with a directional vocation to Northern Africa countries. The fourth key difference is the existence of intermodal products from Paris-CDG which are tailored to attract air-air passengers towards the rail-air alternative they promote and which, in one case, have now replaced the air-air option (the Air France Brussels link by Thalys). These products offer integrated ticketing, schedule coordination, and end to end check-in for many destinations, resulting from cooperation between operators towards selling intermodality. At Lyon, the lack of an intermodal product is a barrier to the development of air-rail intermodality. The key differences found are all relatable to our critical factors: the first three refer to network context (airport size in passenger volume, rail frequencies and provision of long-haul flights) and the fourth (provision of intermodal products) refers to integrated ticketing and information.

For case study 3, our attempt to transfer results to Portugal focused on Lisbon airport because high-speed rail infrastructure integration is more likely to be a possibility than for Porto, Beja or

Faro, at this time. The Portuguese high-speed rail network could potentially include a stop at a possible future airport which is to serve the urban agglomeration of Lisbon. That possibility was the basis for this study, where we tried to find if there are conditions for air-rail intermodality success with Lisbon as an intermodal interchange and which main factors need to be taken into account when assessing such a possibility. We based our study on the high-speed rail network which was discussed and assessed in 2004 for Portugal.

Lisbon airport is not a major European hub, although there is a potential for growth as a directional hub towards South America and possibly some destinations in Africa. Intercontinental passenger traffic at Lisbon airport has actually grown strongly in the last years – frequencies for flights to Brazil have been increasing and diversification of destinations in Africa has also been impacting intercontinental demand. Passenger values are average – passenger volume has also grown in the past decade at an average annual rate of 4,1% and Lisbon airport was, as of 2010, the 29th European airport in passenger volume (ANA, 2011) – and potential catchment within 3 hours direct rail journey time will be large with the implementation of the high-speed rail network. Assessment of an air-rail intermodality project in Lisbon should provide answers to the following questions:

- Will there be enough demand to justify high rail frequencies, including intermodal and local demand? High rail frequencies, together with schedule coordination, should guarantee short transfer times, preferably under 3h30, which is the highest value we found in our case studies.
- Will the expected provision of long-haul flights from Lisbon airport be sufficiently attractive to capture demand from other hubs? Or will the opposite happen?
- Is there operator interest in setting up intermodal products at Lisbon airports?

8. Conclusions

Air-rail intermodality projects involve considerable capital and operating costs and require ambitious goals and strong cooperation among actors.

We have defined five critical factors which determine air-rail intermodality success: infrastructure integration, network context, overall travel time and transfer time, integrated ticketing and information. Additionally, legal and regulatory constraints strongly determine context and must be dealt with intensively during planning stages. Governance factors were also considered a key determinant of success for planning, implementing and operating these multi-operator projects which require high levels of cooperation and coordination. In this context, best practice shows that the existence of an intermodal coordinator or manager to coordinate actors and activities will facilitate air-rail intermodal operation.

Case study results illustrate the importance of the critical factors we considered earlier, as well as the role of cooperation and governance in air-rail intermodality success. Case study 3 suggests that it is possible to gather conditions for successful integration of Lisbon airport in the high-speed rail network, and proposes the consideration of 3 main issues when assessing such a possibility: sufficient demand to justify adequate rail frequencies, sufficient provision of long-haul flights from Lisbon airport to capture demand and the existence of operator interest in offering intermodal products.

Although best practice definitions and guidelines exist for intermodality in general, there doesn't seem to be a recipe for air-rail intermodality success. Further research is needed on how factors impact passenger demand in order to develop better decision support tools for air-rail intermodality projects.

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